

## Photonic Bandgap (PBG) Shielding Technology

**Photonic Bandgap (PBG) shielding technology** is a new approach to designing electromagnetic shielding materials for mitigating Electromagnetic Interference (EMI) with small, light-weight shielding materials. It focuses on ground planes of printed wiring boards (PWBs), rather than on components. Modern PBG materials also are emerging based on planar materials, in place of earlier, bulkier, 3-dimensional PBG structures. Planar PBG designs especially show great promise in mitigating and suppressing EMI and crosstalk for aerospace designs, such as needed for NASA's Constellation Program, for returning humans to the moon and for use by our first human visitors traveling to and from Mars.

Photonic Bandgap (PBG) materials are also known as artificial dielectrics, meta-materials, and photonic crystals. General PBG materials are fundamentally periodic slow-wave structures in 1, 2, or 3 dimensions. By adjusting the choice of structure periodicities in terms of size and recurring structure spacings, multiple scatterings of surface waves can be created that act as a forbidden energy gap (i.e., a range of frequencies) over which nominally-conductive metallic conductors cease to be a conductor and become dielectrics.

Equivalently, PBG materials can be regarded as giving rise to forbidden energy gaps in metals without chemical doping, analogous to electron bandgap properties that previously gave rise to the modern semiconductor industry 60 years ago. Electromagnetic waves cannot propagate over bandgap regions that are created with PBG materials, that is, over frequencies for which a bandgap is artificially created through introducing periodic defects.

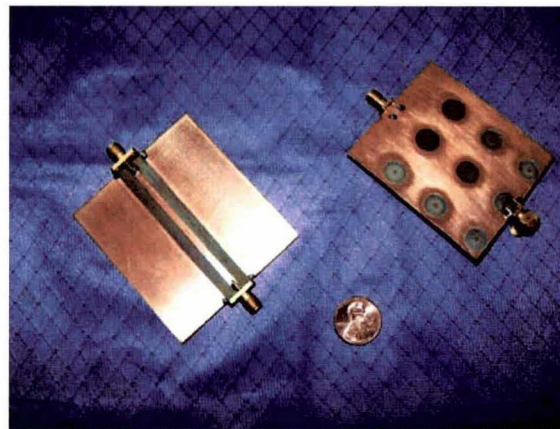


Figure 1 PBG Design Exemplar, 2.8-6.0 GHz Bandgap Region

The PBG ground, being an artificial dielectric, has unique properties. Surface currents over some frequency ranges behave as if on a standard conductive metallic ground plane, providing no attenuation to microstrip or co-planar waveguide transmission lines. Yet, over a bandgap region, where the ground plane becomes a dielectric, signals are reflected or attenuated. Lowpass filters with high power capability can be implemented with nothing more than a transmission line run over a PBG ground, with no additional components being required.

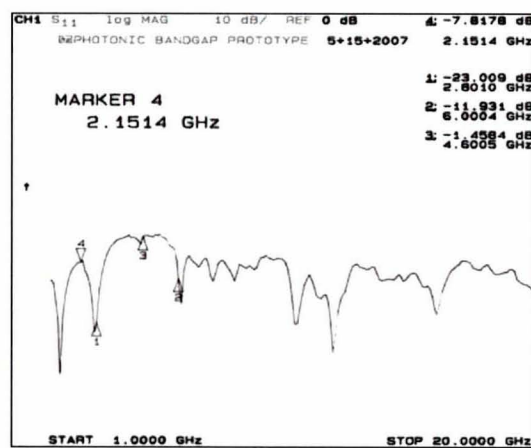


Figure 2 Measured S11 shows bandgap region over 2.8-6.0 GHz

Similarly, crosstalk between adjacent circuits arrayed on common PWBs can easily be controlled and eliminated. It is even possible to rework existing PWB designs that have failed to meet signal isolation requirements, through mechanical machining of the ground plane of the PWB, to achieve additional isolation when needed.

Another property of these materials also makes PBG technology valuable. Any planar antenna placed above a ground plane conductor has a problem as the antenna thickness is reduced and the spacing to ground is reduced. The tangential Electric-field (E-field) for a field terminating on a conductive ground tends to zero as the spacing of the antenna above a conductive ground plane approaches zero. The effect of this phenomenon is that antennas, to meet minimum bandwidth requirements, often have to be at least a certain minimum thickness to prevent coupling the antenna with its image in the ground plane and electromagnetically 'shorting' the antenna. PBG materials thus provide a means for miniaturizing antennas, without necessarily destroying operating bandwidths of the reduced size antennas.

Similarly, patch antennas, often used on surfaces of missile and spacecraft designs, typically couple a large portion of their transmitted power into the adjacent metallic skin next to the patch antenna – some patch antennas lose upwards of 3 dB, that is,  $\frac{1}{2}$  of the power that is provided goes into heating the metallic surface or skin of a missile or spacecraft. Using a ring of PBG groundplane material around the patch antenna can prevent much of this power loss, effectively doubling transmitted power levels for the same power drain, or,

equivalently, doubling battery life for the same transmitted power levels.

PBG technology, not yet 10 years old, can provide a lighter and lessened volumetric size impact while preventing crosstalk among digital and analog radio frequency (RF) circuits. It also can prevent oscillations from arising across high gain RF amplifier stages.

A future vision of a more flexible spacecraft, payload, and missile EMI mitigation technology is emerging in NASA's laboratories, based in part on photonic bandgap shielding technologies. Such technologies can seamlessly extend existing designs with improvements in EMI shielding capabilities, while introducing improvements in terms of effective isotropic radiated power (EIRP) levels for new designs. PBG technology also holds great promise for preserving the utility of existing missile and spacecraft designs, while improving or eliminating crosstalk shortcomings, simultaneously achieving life-cycle cost-savings and increased operational flexibilities for meeting new needs. The ultimate goal, of introducing improvements to EMI shielding technologies, while increasing Range safety, and lowering life cycle costs, appears feasible.

*Contact: Dr. Gary L. Bastin, ASRC Aerospace,  
Mailstop: ASRC-10, Kennedy Space Center, FL  
32899 (Gary.L.Bastin@nasa.gov, (321) 867-9275)  
<http://www.ustdc.com>*

*This ongoing research is sponsored by NASA's  
Kennedy Space Center.*

GB082007